

Studies on Strength and Durability of Concrete Made with Manufactured Sand

Ajay Kumar, Bikaram Nirala

Assistant Professor, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India

ABSTRACT

Many academics throughout the world have been interested in the use of artificial sand in concrete. The growing demand for fine aggregate for the needs of building is greater than the supply of limited natural sand that is currently available. It is suggested that the physical characteristics of naturally occurring river sand and synthetic sand be compared (M-sand). The M30, M40, and M50 mixtures were the subjects of the current study. By varying the relative amount of M-sand from 0 to 100%, the modulus of elasticity (MOE) was assessed. The abovementioned mixes were also tested for sorptivity and impact resistance to determine the ideal percentage of manufactured sand. Moreover, microscopic analyses using electron dispersive spectroscopy (EDS) and scanning electron microscopy (SEM) were carried out. With an increase in mix grade, MOE and resistance to impact loading both improved. Yet, as concrete grade and M-sand content increased, sorptivity was found to decrease. Also, a comparison between experimental MOE values and IS code results was done. According to microscopic investigations, M-sand has an angular and rough surface in comparison to natural sand, which is thought to be the cause of the material's improved MOE and impact resistance as well as its decreased sorptivity.

KEYWORDS: *impact resistance, modulus of elasticity, manufactured sand, sorptivity*

How to cite this paper: Ajay Kumar | Bikaram Nirala "Studies on Strength and Durability of Concrete Made with Manufactured Sand"

Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-2, April 2023, pp.538-542, URL: www.ijtsrd.com/papers/ijtsrd55090.pdf



Copyright © 2023 by author (s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



I. INTRODUCTION:

Concrete has frequently been used as a building material for the nation's sustainable development. The demand for fine aggregate has skyrocketed as a result of the growing use of concrete. The natural river sand, however, has been utilised as a fine aggregate for concrete. Because it is a natural resource, fine aggregate used in concrete production eventually runs out. Due to its decreasing availability and rising transportation costs from the riverbed to the construction site or concrete batching plant, using natural river sand has become exceedingly expensive. Moreover, removing the natural sand from a riverbed alters the river's direction, the local water table, and consequently environmental problems. The global research community has been interested in this cascade impact of using natural river sand. Making concrete with manufactured sand (M-sand) rather of regular river sand is one way to solve this issue. The natural granite stone is crushed in vertical shaft impact

crushers to produce M-sand, which is then screened to remove any fine particles smaller than 4.75mm. The impact of M-sand on the strength and durability of concrete has been the subject of certain investigations. This is a discussion of a few significant important research findings. According to Patel and Pitroda [1], the MOE decreased when fly ash was present relative to the control mix. When the 40% of cement was substituted by fly ash, it was revealed that MOE decreased by 53.79% and 46.43% for concrete grades M25 and M40, respectively. According to Pitroda and Umrigar [2], similar results were obtained when fly ash and hypo sludge were used as cementitious materials. It was demonstrated that replacing 40% of the cement with hypo sludge and fly ash was successful. For M25 and M40 grade mixtures, volume caused a drop in MOE of 32.50% and 31.12%, respectively.

II. EXPERIMENTAL PROGRAM

Materials

The following lists the materials used for the current experimental study and the pertinent attributes.

Cement

For the experimental work, ordinary portland cement (OPC) of grade 53 conforming to IS 12269 - 1987 was employed. Table No. 1 displays the OPC's characteristics.

Property	Value
Specific gravity	3.15
Initial setting time	33 min.
Final setting time	385 min.
Fineness $m^2 / Kg.$	270.80
Soundness	1.00 mm
Standard consistency	31%
Compressive strength 7 days	43.50 MPa
Compressive strength 28 days	MPa

Table-1. Physical properties of cement

Coarse aggregates

By breaking locally accessible granite stone, aggregates were produced. The aggregate's largest possible size was 20 mm. The study used a combination of aggregates with sizes of 20 mm and 12.50 mm. IS 389-1989 was verified for the aggregates.

Property	Coarse aggregate	Fine aggregate	
		River sand	M-sand
Specific gravity	2.70	2.60	2.45
Bulk density (kg/m^3)	1510	1460	1556
Water absorption (%)	0.45	1.15	1.00
Moisture content (%)	0.85	1.10	1.15
Aggregate impact value (%)	12.50	-	-
Fineness modules	6.67	3.44	3.54
Fineness particles Less than 150mm (%)	-	4.14	5.30

Table-2 Physical properties of coarse aggregate and fine aggregates

Fine aggregates

Locally available natural sand was used as fine aggregate. The fine aggregate used was confirmed to IS 389-1989. The physical properties calculated are presented in Table-2. Locally available granite boulders were used to obtain the artificial sand. The granite boulders were fed into the crusher and output was thoroughly screened to the required size and shape to eliminate the unwanted micro- fines. Then the screened fine aggregate was washed with water to obtain clean M-sand. The physical properties of manufactured sand were evaluated and are presented in Table-2. It was found from the sieve analysis that both natural river sand and M-sand were in zone-II.

Mix proportion

According to the requirements outlined in IS: 10262-2009(15) and IS: 456-2000, concrete mixes M30, M40, and M50 grades were created (16). Table 3 displays the mix proportions developed and the w/c ratio utilised for the control mix and the mix with 100% M-sand replacement.

Mix ID	M30		M40		M50	
	Mix proportion	w/c ratio	Mix proportion	w/c ratio	Mix proportion	w/c ratio
M1	1:2:3.53	0.45	1:1.69:3.13	0.40	1:1.54:2.97	0.35
M11	1:1.88:3.53	0.45	1:1.6:3.13	0.40	1:1.45:2.97	0.35

Table-3 Mix proportions and w/c ratio for various grades.

III. TEST METHODOLOGY

Modulus of elasticity

The moulds used were cylindrical, 150 mm in diameter and 300 mm long. The concrete specimen samples were left in the moulds for 24 hours after being cast. After 24 hours, the specimens were taken out of the moulds and allowed to cure for 28 days in the water tank. The sample was maintained in an open environment for two to three hours prior to testing before being taken for the test. The dial gauge was positioned so that the gauge points were symmetrical around the specimen's centre. After an average stress of (C+5) Kg/cm² was obtained, the load was applied continuously at a rate of 140 Kg/cm²/minute, where "C" stands for the average compressive strength of the cubes, calculated to the nearest 5 Kg/cm².

The load was maintained at this stress for at least one minute before being gradually lowered at an average stress of 1.5 kg/cm², at which point the reading was collected. Once more, the load was applied at the same pace until the compress meter readout reached an average stress of (C + 1.5) Kg/cm². The reading was recorded after the load was gradually decreased to 1.5 Kg/cm². The extensometer results were taken after the third application of the load.

Impact resistance

The impact test was conducted in accordance with the methods for impact testing that ACI Committee 544 has advised. The test involved repeatedly striking a 64mm (2.5 inch) hardened steel ball that was put on top of the centre of the cylindrical specimen (disc) with a hammer that weighed 44.7N (10 lb) from a height of 457mm (18 inch). The test was carried out until it failed. The number of blows for the initial fracture and the ultimate crack on each specimen were counted. The former figure gauges the number of blows needed to start a crack that is visible, whereas the latter gauges the number of blows needed to start cracks that eventually fail.

Sorptivity

In accordance with ASTM C 1585-04, cylindrical specimens of 100 mm x 50 mm were cast to measure the sorptivity. The samples were cured for 28 days in water. For three days, concrete samples were oven-dried at 50 °C. The samples were kept in a sealable container for 15 days after 3 days. measures were taken measures are taken to ensure that the specimen has little to no contact with the container walls, allowing unrestricted circulation of air around it. The specimens' weights were recorded and their sides were sealed after 15 days. The specimen's average diameter was measured, and the top surface was sealed as well. After placing the samples in water, the stopwatch was started. At intervals of 1 minute, 5

minutes, 10 minutes, 20 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days, and 8 days, the mass of the specimen was recorded.

IV. RESULT AND DISCUSSIONS

Modulus of elasticity

According to Table 4, it is clear that adding more M-sand improved the MOE up until mix M8, which contained 30% river sand and 70% M-sand. The MOE of concrete was adversely affected by additional M-sand addition. Also, it can be shown that with an increase in concrete grade, greater MOE was seen for the same mix. While there was a greater performance disparity between M30 and M40 in MOE, there was a smaller performance gap for the mixes M40 and M50. For concrete of the M30, M40, and M50 grades, respectively, a maximum increase of roughly 11%, 10%, and 12% in MOE was noted.

Mix	Modulus of elasticity (GPa)		
	M30	M40	M50
M1	33.10	39.40	39.90
M2	33.50	39.80	41.20
M3	33.80	39.80	41.40
M4	34.20	39.90	41.80
M5	34.80	41.20	42.00
M6	35.50	41.40	42.80
M7	36.00	41.80	43.60
M8	36.40	43.20	44.80
M9	36.80	42.20	43.00
M10	35.50	41.80	42.80
M11	35.00	41.20	42.60

Impact resistance

Table 5 lists the number of strikes the specimens received prior to the initial crack and the final crack. At first look, it is clear that an increase in concrete grade provided greater impact loading resistance for a given proportion of river sand and M-sand. It was found that the specimen that required more blows to cause the initial crack also required more blows to cause the final crack.

Mix	No. of blows	
	First crack	Rupture
M30-M1	45	99
M30-M8	51	116
M30-M11	49	112
M40-M1	98	135
M40-M8	109	147
M40-M11	107	143
M50-M1	104	145
M50-M8	124	154
M50-M11	121	147

Table-5. Impact resistance of various mix proportions.

Sorptivity

The water absorption capabilities of various concrete specimens in a unilateral orientation. In order to calculate the initial rate of absorption (IRA) and secondary rate of absorption, the total weight of water absorbed across a range of time periods was measured and shown on graphs (SRA). With the identical ratios of river sand and M-sand, it was found that higher-grade concrete had lower IRA and SRA. Also, it was observed that IRA and SRA values decreased as the proportion of M-sand increased.

V. CONCLUSIONS

We have learned more about the performance of M-sand in concrete through experimental tests that were done both with and without M-sand. The experimental investigation can be used to draw the following findings.

- The mix design of concrete utilising M-sand as a partial and full replacement of cement was developed using a weighted average technique based on the specific gravity of the river sand and the M-sand.
- The presence of M-sand resulted in a small improvement in MOE. As comparison to other ratios, a relative percentage of 30% Natural River sand and 70% M-sand produced better MOE.
- The impact resistance of concrete was positively impacted by the presence of M-sand. M8 mix outperformed the control and M11 mixes in terms of performance.
- Compared to the control mix, the addition of M-sand slowed the rate at which water was absorbed.

VI. REFERENCES

- [1] R. P. K. Patel and J. K. Pitroda. 2003. Calculation of Elasticity for concrete using thermal Industrial waste. Global research Analysis. 2(1): 42-43.
- [2] J. K. R. Pitroda and F.S. Umrigar. 2013. Evaluation of modulus of elasticity of concrete with partial replacement of cement by thermal Industrial waste (fly ash) and paper Industry waste (hypo sludge). International Journal of Engineering science and Innovative Technology. 2(1): 133-138.
- [3] U. V. Tilak and A. N. Reddy. 2015. Effect of different percentage replacement of weathered aggregate in place of Normal Aggregate on young's Modulus of concrete to produce high strength and flexible/Ductile concrete for use in Railway concrete sleepers. SSRG International journal of Civil Engineering. 2(11): 24- 29.
- [4] G. N. Manguri, C. K. Karugu, W. O. Oyawa, Abuodha and P. U. Mulu. 2013. Partial replacement of natural river sand with crushed rock sand in concrete production. Global Engineers & Technologists review. 7-14.
- [5] M. R. Lokeswaran and C. Natarajan. 2015. Non Destructive Investigation on the Effect of Locally available manufactured sands in concrete. International Journal of earth sciences and Engineering. 8(2): 184-188.
- [6] T. Shanmugapriya, K. S. Raja and C. Balaji. 2016. Strength and durability properties of high performance concrete with manufactured sand. ARPN journal of engineering and applied sciences. 11(9):6036-6045.
- [7] P. Magudeswaran and P. Easwaramurthy. 2016. High performance concrete composite using manufactured sand. International Journal of Advanced Engineering Technology. 7(1): 736-742.
- [8] J. R. V. Solanki and J. K. Pitroda. 2013. Study of Modulus of Elasticity of concrete with replacements of cement by Hypo Sludge Waste from paper industry. Global Research Analysis. 2(1): 40-41.
- [9] Y. Liu, C. Lee and K. S. Pann. 2009. Effects of fiber and silica fume reinforcement on abrasion resistance of hydraulic repair concrete. Proceedings of the 2nd International Conference on Concrete Repair, Rehabilitation and Retrofitting. Taylor Francis Group. 877-880.
- [10] K. S. Abhinav and N. S. Rao. 2106. Investigation on impact resistance of steel fibre reinforced concrete. International Research Journal of Engineering and Technology. 3(7): 954-958.
- [11] Indian Standard Specifications for 53 Grades of Ordinary Portland cement Concrete, IS: 12269-1987, Bureau of Indian Standards, New Delhi.
- [12] Indian Standard Specification for coarse and fine aggregates from natural sources, IS: 383-1989 (reaffirmed 2002), Bureau of Indian Standards, New Delhi.
- [13] Standard Specifications for Chemical Admixtures for Concrete, ASTM C-494, 2004.
- [14] Indian Standard Specification for concrete Admixture, IS: 9103-1999 (Re-affirmed 2004), Bureau of Indian Standards, New Delhi.
- [15] Indian Standards for plain and reinforced concrete code of practice IS: 456-2000, Bureau

- of Indian Standards, New Delhi.
- [16] Indian Standards Concrete Mix proportioning guidelines IS: 10262-2009, Bureau of Indian Standards, New Delhi.
- [17] Indian Standards for Methods of test for strength of concrete, IS: 516-1959 (re affirmed 2004), Bureau of Indian Standards, New Delhi.
- [18] American Concrete Institute Committee 544 - Fibre reinforced Concrete, ACI: 544 (2008), American Concrete Institute.
- [19] Standard Test Method for Measurement of Rate of Absorption of Water by Hydraulic- Cement Concretes, ASTM C1585, ASTM International, 2007.

